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GEOLOGICAL SURVEY OF CANADA
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REPORT
UPON THE
CARBONIFEROUS SYSTEM OF NEW BRUNSWICK
WITH
SPECIAL REFERENCE TO WORKABLE COAL.

BY
L. W. BAILEY, LL.D.

1902



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EXCELLENT MAJESTY

1902

TO ROBERT BELL, M.D., Sc. D., L.L.D., F.R.S.
Acting Director of the Geological Survey.

SIR,—I have the honour to transmit for your consideration the following report upon the Carboniferous system of New Brunswick, made as the result of instructions received from the late director, Dr. G. M. Dawson, and subsequently renewed by yourself.

The report has special reference to the subject of the probable productive capacity of the New Brunswick coal-measures, and embraces a discussion, based upon personal observation, of the various considerations from which conclusions as to that capacity may be drawn. It is accompanied, in the form of an appendix, by records of the more important borings, and by a bibliography bearing upon the subject.

The report is concurrent with one by Mr. H. S. Poole, upon the comparative aspects of the coal formation of New Brunswick and Nova Scotia, in the preparation of which a large part of the former province was visited by that gentleman in company with myself during the past summer, when the topics here presented were fully discussed by us.

I have the honour to be, Sir,
Your obedient servant,

L. W. BAILEY.

FREDERICTON, March 20, 1902.

THE CARBONIFEROUS SYSTEM OF NEW BRUNSWICK.

Ever since the time of the first discovery of coal in the province, that discovery being co-incident with the first exploration of the Grand Lake region in 1782, interest in the existence of the mineral, and speculations as to its probable amount have found expression. The observations of Dr. Abraham Gesner, between the years 1839 and 1841, served greatly to intensify this interest, both by the discovery that Carboniferous rocks occupy in the province an area equal to at least one-third of its entire surface, and by the statement, now believed to be unwarranted, that the thickness of the formation and the number and size of its coal deposits were in keeping with that large superficies. Borings made at Grand Lake and elsewhere seemed to support, at least in popular estimation, the belief thus expressed, and even though some years later, as a result of the work of the Geological Survey, it was (in 1872-73) shown that the Grand Lake basin, the only one actually yielding coal in appreciable quantities, was really very thin, and that the seam of 26 inches, long known and worked near the surface, was the only one there present, people unacquainted with geological data and methods were loth to accept the conclusion arrived at, and still contended for the probable existence of other and larger seams. Then, too, the Grand Lake basin, being but a very small part of the entire area occupied by Carboniferous rocks, the question naturally arose whether there might not be other basins as well as this, and whether some of these, at least, might not prove to be more productive. To ascertain whether or not this is the case would seem at first to be an easy matter, but when it is understood that over vast tracts, indeed over almost the entire field, the coal-bearing rocks are very nearly horizontal, the upper strata thus covering all beneath them, except so far as they are revealed by erosion along river valleys, it will be readily seen that the determination of correct conclusions, other wise than by boring, is very difficult. Such borings, it is true, have been made at a number of points, but with one or two exceptions they have been in the extreme western part of the coal field, where other facts all lead to the inference that the coal-measures

Historical
summary.

Difficulty of
arriving at
satisfactory
conclusion.

are thin. On the other hand, in the eastern part of the province, where the coal basin is widest, where the beds are nearest to its centre, and where they become directly continuous with the highly productive Carboniferous rocks of Nova Scotia, the country is, except at one or two points, a *terra incognita* as regards what lies below the surface. It would seem, therefore, very desirable that this ground should be thoroughly tested, but before incurring the expense necessarily involved in instituting any extensive series of borings, all available facts bearing upon the choice of location, probable depth, etc., need to be carefully collected and estimated. It is to aid in this direction that the present report has been prepared.

Object
of present
report.

It will be obvious that the question involves many different considerations, thus, the topography of the country, as being directly determined by the attitude of the underlying strata, has an obvious bearing upon the question of that attitude, as this has upon the position and spread of any coal seams which may be present. The erosion which the country has undergone, whether by the operation of glaciers or rivers, or both, has led to the removal of vast quantities of rock, and it is a subject for consideration as to how much has been thus removed, and whether such removal involved any productive coal-measures or not. In the river valleys and along the coast are the natural sections which afford the only information, short of boring, which the region offers, and these need to be carefully studied and compared. The evidences of displacement, whether by differential movements involving large areas, or confined to particular lines determining faults, require consideration. The fossils, obtained at many different localities, need to be compared, with a view to determine the horizons they represent. And, finally, a comparison of the coal-bearing rocks of New Brunswick with those of Nova Scotia, where the system is so much better displayed and has been so long and carefully studied, is of the utmost importance, for such comparison should tend to show whether the surface rocks of New Brunswick are the representatives of the lower portion only of the coal formation (in which case it would be useless to seek for serviceable seams) or of the middle or upper. The data afforded by new borings need also to be collated and compared.

Comparison
of fossils
necessary.

In the following pages an attempt will be made to discuss the question of possible coal supply from each of these several stand-points, with the exception of that of a comparison of the Carboniferous systems of New Brunswick and Nova Scotia, which will be the subject of another and concurrent report by Mr. H. S. Poole.

TOPOGRAPHY

Ever since the publication, some forty years ago, of Prof. J. P. Lesley's classical work, entitled "Coal and its Topography", the intimate relationship between the surface features of a coal producing country and its underground structure has been recognized, and the study of the one, regarded as capable of throwing important light upon the other. This is more markedly true of a highly disturbed and partly mountainous region like that of Pennsylvania, to which the above named work mainly applies, but even in the case of a comparatively flat and unchanged district, such as is represented by the central coal-fields of New Brunswick, some valuable deductions may be drawn from the recognition of this relation.

The coal-field in question has the general form of a triangle, of which two sides, converging westwardly, are bounded by pre-Carboniferous rocks, highly disturbed and altered, while the third, forming the base of the triangle, and having a length of about one hundred and forty miles, has no natural barrier other than the Gulf of St. Lawrence. As compared with the hill ranges which confine it, the tract is, with few exceptions, low, and, except for river valleys, it presents no marked inequalities of surface, while, as compared with the sea, its elevation would probably rarely exceed six hundred feet and the general average would not be over four hundred. It is thus a great peneplain with a gentle eastward inclination, of which the irregularities are the results of erosion rather than of differential movements. At the same time, a study of the drainage system shows that, as subordinate to the general form of a broad and shallow basin, several minor undulations may be distinguished, separated by low divides, of which some are of ancient and others probably of comparatively recent origin.

The contrast of level exhibited by the central coal-field as compared with that of its bounding sides is very noticeable wherever opportunity of surveying one from the other is afforded. Thus, from Spring Hill or other high land north of Fredericton, looking to the south and south-west, the eye appears to wander over a great plain, through which the St. John river winds a tortuous course, until in the distance the picture finds a natural setting in the range of Lower Carboniferous and older hills which bound the coal-field in that direction. So, as viewed from the ridge north of Moncton, known as Indian ridge, so uniform is the surface and relatively so low, that again all minor inequalities become lost, and one looks in vain for anything by which the local monotony of the landscape may be broken. Finally, along the line of the Inter-

Relation of
topography to
structure.

Form and
limits of coal
field.

Minor
undulations.

Level type of scenery.

colonial Railway, from near Moncton to the vicinity of Bathurst, the flat unbroken character of the country, with consequent imperfect drainage, determines, except at a few points, scenery wholly devoid of interest, and the tract is also for the most part unfitted for cultivation. Even where, as in the case of the Nashwaak and Miramichi rivers, a more attractive type of scenery prevails, and good farming lands occur, these are almost wholly confined to the river valleys, the hills bounding which, as seen from the opposing side, appear nearly level-topped.

Minor depressions.

Of the several minor depressions indicated by drainage, the following may be noted as of importance in relation to the subject of this report, viz :—1. The Oromocto tract, including the whole of the Carboniferous area west of the St. John river in Sunbury and York. 2. The Grand Lake basin in Central Queens. 3 The Nashwaak area in York. 4. The S.W. Miramichi area, and (5) the Gulf area, including the valleys of the Richibucto, Buctouche, etc., to which, perhaps, are to be added the region of the Baie des Chaleurs and that of Shediac and Dorchester. It is not yet certainly known whether in all cases the divides separating these areas are results of surface changes, due to glacial or later agencies, or whether, as indicated in some instances by Dr. R. W. Ells, they correspond to the results of deep seated movements, but, in the case of the Grand Lake basin at least, the geologic boundary is nearly coincident with the physiographic one, and this may be true of others also. The highest divide would appear to be that lying between Cross creek, a tributary of the Nashwaak, and the S.W. Miramichi at its junction with the Taxes, the elevation here, according to the levels of the Canada Eastern Railway, being 566 feet.

Conclusions suggested.

The general conclusion suggested by the above review of the topography of the main New Brunswick coal-field would seem to be that the conditions connected with its origin were uniform, or nearly so, over the greater portion of its extent, such diversity as now exists being the result of causes operating long subsequent to the time of disposition of the strata occupying it. Hence, what is true of one portion of it is presumably true of all. Seams of coal, if existent, would be expected to spread widely, with little variation in thickness. If the strata at one point are those of the inferior or barren measures, it would seem probable that other portions are not far from the same horizon. It does not, however, follow that because the formation is

NOTE—Between Newcastle and Bathurst the mean elevation of the plateau is 414 feet, the summit on the Intercolonial Railway being 521 feet.

Between Moncton and Barnaby river the plateau has a lower mean elevation on the line of the railway of 266 feet.

proved by boring to be thick (or thin) at one point, it is necessarily so in others, as the horizontal strata may and probably do rest on an uneven floor of older rocks, and will be thick or thin, as the inequalities of the latter come near to or retire from the surface. The thickness may also, to some extent, be an accident of deposition or erosion.

EROSION.

In any consideration of the Carboniferous system of New Brunswick it is always important to recognize the fact that the representation of that system now revealed is but a fragment, relatively small of what it once was. Former greater extent of Carboniferous area.

In the first place, it is obvious that the great central basin, widening to the eastward, did not, in Carboniferous times, terminate with the present gulf coast. Everywhere that coast is low; everywhere the adjacent waters are shallow; and at no point in the Gulf of St. Lawrence east of New Brunswick are they deep. Prince Edward Island is separated from the mainland only by narrow straits, and the rocks of that island are largely, if not wholly of newer strata. About Baie Verte the Carboniferous rocks of New Brunswick become continuous with those of Nova Scotia, while rocks of Lower Carboniferous age crop at Smiths and the Magdalen islands and skirt the western coast of Newfoundland, part of the western shore of Cape Breton and the southern shores of the Gaspé peninsula.

Thus, all around the portion of the Gulf of St. Lawrence inclosed by the districts referred to, rocks belonging to or not widely separated from the Carboniferous system occur, and suggest the conclusion that they were at one time continuous over the intervening area. In other words, the portion of the widespread Acadian Carboniferous formation now above the sea-level is but a small fraction of its former extent, while much the thickest and deepest, and presumably the most productive portion, is now either submerged or worn away.

Nor is it only in this direction that there is evidence of loss. Carboniferous outliers. Around the other borders of the great central basin, where the older rocks come out from beneath those of the Carboniferous system, there is abundant evidence that these latter once spread more widely. Thus, along the western edge of the coal-field in York and Sunbury, in Cork settlement and about Oromocto lake, the edge of the Carboniferous peneplain is in the form of a long and steep escarpment, overlooking the valley of the Magaguadavic river, occupied by pre-Carboniferous rocks, while isolated patches of the first named system are found much

farther to the westward, indicating a former considerable extension in that direction. To the north of Fredericton also, in the valley of the Keswick, above Cardigan station on Gardens creek and in Myshrahl settlement, the same conditions may be observed. Moreover, some of the isolated Carboniferous areas in this direction are so situated as to indicate that rocks of this age at one time covered a large portion of northern as well as central and southern New Brunswick. Thus, in the parish of Prince William, in York county, occurs a small area of coal bearing rocks, resting unconformably upon what are believed to be Silurian slates, and upon granite, the interval between them and the great central coal-field being not less than thirty miles. So, between the two main branches of the Beccaguimic river, in Carleton county, and at a distance of about fifty miles from the central basin, is a similar isolated area, of considerable size, while the distribution of boulders indicate that several such areas exist between the last named river and the Lower Carboniferous tract of the Tobique. It is altogether probable that these were once connected with each other and with the central field, for their elevated position, much higher than any portion of the latter, as well as their structure and relation to the subjacent rocks, are against the supposition of their representing basins of original and separate deposition. The elevation of some of these higher Carboniferous rocks is nearly one thousand feet above the sea, and though the contrast between this and the ordinary level of the coal-measures in Queens and Sunbury may possibly in part be accounted for by differential movements, it can hardly be doubted that the facts given indicate an enormous amount of erosion, and the removal of Carboniferous rocks from vast areas once covered by them. This vast erosion is to be assigned to several periods. It is certain that after the time of deposition of the Lower Carboniferous strata, they were largely denuded, for at several widely separated points, as at Prince William in York county, and Coal creek and Newcastle in Queens county, the coal-measures rest on the earlier Palaeozoic rocks, without the interposition of Lower Carboniferous deposits, as though the latter had first been swept away. Some of the coarse grits again in the upper part of the coal measures have been observed (by Mr. Poole) to contain rounded fragments of *coal*, indicating the breaking up of seams of the latter subsequent to their formation. It is probable, however, that a large part of the waste is to be ascribed to the glacial period, all parts of the coal-field showing abundant evidence of extensive glaciation, while the amount and distribution of the drift has been largely influential in determining the distribution and thickness of the mantle-covering, as well as the course and character of the existing drainage channels.

Elevation of
some of the
carboniferous
rocks.

Period of
erosion.

The subject of erosion is of interest in another way. The channels last referred to, together with the coastal sections, afford, with the exception of borings, almost the only information obtainable as to the nature and arrangement of the rocks of the district. Erosion valleys.

The details of these sections in the gray rocks will be discussed in the sequel, but it may be pointed out here that in no case is any considerable thickness of strata revealed, and it is probable that all in the centre and eastward represent nearly the same horizon. Among them, as affording a nearly complete natural section, albeit a shallow one, across the larger part of the central basin, may be mentioned those afforded by the Nashwaak and Miramichi valleys, traversed by the Canada Eastern Railway, along the sides of which, and often for considerable distances, the cut edges of the strata are exposed in nearly vertical bluffs, sometimes 100 feet in height or more. In eastern Queens county similar bluff exposures characterize the Newcastle and Salmon river streams, while in western Queens and Sunbury they are repeated in the tributaries of the Oromocto, in the Otnabog and elsewhere. In most instances the eroded beds are those of the coal-measures (gray sandstones and conglomerates, with thin seams of coal), but on the Newcastle river the underlying Lower Carboniferous and volcanic rocks are revealed, while on Coal creek and some of the tributaries of the Canaan river, still older Palaeozoic rocks have been brought to view. At no one point is a thickness of more than 150 feet of Carboniferous rocks exposed, though, even with a slight inclination, a lengthened series of exposures may represent much more than this. Natural sections.

The coast sections illustrate the same features, though in a different way. By far the most instructive is that afforded by the shore of the Baie des Chaleurs east of Bathurst. Here for a distance of fifteen miles or more, especially between the villages of Clifton and Grand Anse, the shore presents an almost continuous series of nearly vertical bluffs, from twenty or thirty to nearly one hundred feet in height, while in places, as at Grand Anse, small adjacent islands exhibit the same precipitous character. Here too the inclination varies so little from horizontality that only by following some easily recognizable bed for a considerable distance can the fact of inclination be made evident. At various points along the gulf shore, as at Carraquette, Church point Coast sections.

NOTE. 1.—The term coal measures as used in this report signifies no more than the series associated with the small seams of coal in the province.

2. Clifton station is 119 feet and Grand Anse 79 feet above sea level.

3. The whole thickness represented in the coast section between Clifton and Shippegan has been estimated at about 400 feet.

and the inner part of Miramichi bay, shore bluffs occur, but are less high and less continuous. Most of this latter shore is very low and without exposures.

ATTITUDES AND UNCONFORMITIES.

It will be readily understood that in any study of the coal formation, whether from a merely scientific or from an economic standpoint, the positions occupied by the strata, considered both by themselves and in relation to different divisions of the system, are of the first importance.

Horizontality
of measures in
central area.

In the great central Carboniferous area, as already pointed out in the discussion of its topography, the strata exposed to view are, with rare exceptions, nearly horizontal. In the very numerous sections exposed along the line of the Canada Eastern railway, following the valleys of the Nashwaak river, Cross creek and the Miramichi river, this is very conspicuous, as it is also about the shores of Miramichi bay and northward. It would however seem, as is more clearly indicated in the coastal sections east of Bathurst, that over most portions of the central field there is a gentle inclination eastward or towards the St. Lawrence gulf. It is also quite certain that there are minor undulations, though partly owing to the prevalence of false bedding and partly to the want of continuous outcrops, these foldings cannot always be clearly made out.

Grand Lake
basin.

One fairly distinct basin is that of which Grand lake, Queens county, is the centre; this being indicated not only by the reverse dips clearly seen on its northern and southern sides, but by the fact that on each of these sides the rim or margin is shown, at least in part, by the coming to the surface of inferior beds. It is very probable that the valley of Coal Branch, in Kent, represents another basin, possibly continuous with the last, and having as its northern margin the swell of land lying between the valley referred to and that of the Miramichi. Doubtless, still other basins exist, but they are so shallow, and at the same time so concealed by soil and forest, that their recognition is difficult or impossible.

Exceptions to
horizontalities.

While very low dips are, as stated, characteristic of the central basin, some notable exceptions occur. Of these, one of the most remarkable is to be seen upon the right bank of the St. John river about four miles above Fredericton, where, over a small area, rocks, not distinguishable in character from the nearly flat coal-measure sandstones, not far off, have an inclination approaching verticality.

This is probably the result of local faulting, such as would be likely to occur near the border of the Carboniferous tract.

The approximate horizontality of strata in the central area referred to above, applies both to the Lower Carboniferous and the overlying coal-measures. These are, therefore, in apparent conformity. Nevertheless, a sort of unconformity is indicated, first, by the frequent occurrence of irregular masses of trap between the two, indicating downward movements and dislocations prior to the deposition of the gray beds; and secondly, by the fact that the latter beds rest upon different members of the Lower Carboniferous at different places, or even upon still older rocks, the last named beds being wholly wanting. Examples of this relation occur north of Fredericton.

It is also important to notice that even where the beds are still horizontal, the rocks of the coal-measures are frequently intersected by vertical faults. These are quite common in the hills about Fredericton as they are also along the Nashwaak valley and elsewhere. Most of them seem to be of insignificant amount, but it is not improbable that there are some of considerable magnitude. For instance it is difficult otherwise to account for the peculiar outline or border of the Carboniferous system as seen north-west of Fredericton, where, upon the east side of the St. John river and its tributary, the Keswick, the pre-Carboniferous rocks are abruptly cut off by Carboniferous sediments, which, with great suddenness, are made to occupy upon one side of this line an area some ten miles wider than upon the other. In the Kings county basin, both the Lower Carboniferous and Carboniferous rocks are usually inclined at low angles, but here exceptions are to be found. Thus, while along the Narrows of the St. John river below the Boar's Head, in the Minister's Face opposite Rothesay and elsewhere, the beds (Lower Carboniferous) are in low undulations, to the east of Rothesay they dip quite steeply, their basest edges forming a series of sharply projecting reefs. About Dunsinane, where the surface rocks are those of the coal-measures, the dips are moderate (from 5° to 14°), but with indications of considerable faulting, and still further east, in the direction of Petitcodiac, like conditions prevail.

In Westmoreland county a remarkable illustration of local disturbance and unconformity is to be seen in the vicinity of Lutz mountain and Indian ridge, north of Moncton.

Disturbance
about Indian
ridge.

The rocks of the first named ridge, as seen in the 'Gorge,' are coarse and hard brownish-red conglomerates, of Lower Carboniferous age, upon the north side of which are heavy beds of gray shale, underlying the overturned conglomerate. Still further north is a ridge of

Albert shales.

felsite breccia, together with hard chloritic granitoid rock, bearing some resemblance to an altered grit, and probably an exposure by denudation of a ridge of pre-Cambrian rocks extending eastward from ridges of similar age in Kings county. Separated from the last named ridge by a somewhat pronounced valley, is Indian ridge or mountain, which, to a large extent is made up of a very dark gray shale, which in general aspect strongly recalls the so-called Albert shales of Albert county. Like these, the somewhat compact rock shows by weathering finely laminated, somewhat wavy layers, resembling sections of wood; but it is not bituminous like the shales last mentioned, nor so tough. In places the beds contain branching vegetable stems resembling *Psilophyton*. Beneath them are hard gray flaggy sandstones, dipping, like the shales, to the southward at an angle of 45° to 55°, a similar strike and dip being preserved throughout the ridge for a distance of four or five miles. From its elevated surface an extensive view is to be had over the much lower and flat country to the north, underlaid by the gray sandstones of the coal-measures, outcrops of which may be seen a little north of the western end of the ridge, as well as to the eastward, where these rocks, encompassing both the Indian ridge and Lutz mountain, connect on the gulf side with the similar beds about Moncton.

Albert
county.

From the great bulk of these shales and their general aspect, it would seem probable that, even though not bituminous, they represent the Albert shales; in which case, if the latter are Devonian, they must also be referred to the same horizon. If this view be correct, we have here another instance of the coal-measures resting unconformably on the older rocks without the interposition of the Lower Carboniferous. With the exception of the areas last described, the rocks of the northern and eastern portions of Westmoreland and the northern part of Albert county continue to exhibit for the most part low dips, with the gray beds of the coal-measures (or in some instances the red beds of the Permian-Carboniferous) mantling and concealing all older strata. But to the south, in the vicinity of the old pre-Cambrian ridges of Albert county, along a corresponding tract in Westmoreland, and finally along the Bay of Fundy trough in both these counties, evidences of physical disturbances in uplifts and dislocations become marked and general, especially as regards the Lower Carboniferous strata, while erosion has given to the details of distribution great irregularity. Through the same erosion also, the Albert shales are brought conspicuously into view, and the correct interpretation of the structure of the region is complicated by the uncertainty as to the true age of the latter. This is not the place in which to discuss this question, but it may be observed

in passing that if the view recently put forth, namely that these shales are Devonian, be the correct one, it will necessarily follow that the same view must be applied to the heavy beds of conglomerate which at various points, as Elgin, Mapleton and Belliveau, are found beneath them, and yet which, except as to position, are indistinguishable from the Lower Carboniferous conglomerates found elsewhere. All the strata of the region, whether below or above the Albert shales, are, like the latter, highly inclined and broken by numerous faults, but, as elsewhere, the movements thus indicated would seem to have taken place prior to the deposition of the gray beds (Millstone Grit), of which the inclination is much lower and more regular. The tract about the old Albert mines, which close by, adjoins the pre-Cambrian hills, is one especially remarkable for its disturbed condition, not the shales only, but the associated rocks, excepting those of the millstone grit, showing great diversity of inclination, while the latter caps them all unconformably, and with a dip which rarely exceeds 10° . Upon the eastern side of the Petitcodiac river, in Belliveau and Taylorville, the red rocks associated with the Albert slates show the same diversity of attitude, ranging from 15° or 20° up to 80° , while the millstone grit beds, as in the peninsula between the Petitcodiac and Memramcook river, show but a very gentle and regular inclination. Strata highly inclined.

In reaching the Bay of Fundy trough and the region about Dorchester, the rocks of the Millstone Grit formation are also found to have been affected by the movements under review. This is especially true along the Albert county coast, where many fine examples of tilted broken and unconformable strata may be seen. A few of these may be more particularly referred to.

About the plaster quarries at Hillsborough the Lower Carboniferous Hillsborough. limestones and gypsums, resting on conglomerates, are apparently in a series of low undulations, with dips not exceeding 30° ; but upon two sides at least these are bounded by faults, bringing down overlying gray beds to the same level. At Hopewell cape are the wonderful illustrations of marine erosion, known as 'The Rocks,' wherein massive brownish red conglomerates of the Lower Carboniferous, dipping shoreward at angles of 30° or 40° and forming bluffs ranging from ten or twenty to one hundred feet in elevation, have been and are being cut by the sea into all sorts of fantastic forms. At Marys point are Marys point. bluffs of gray and purple sandstone dipping S. 20° W. $< 45^{\circ}$, in which extensive quarrying operations were at one time carried on, and similar beds, abounding in plant remains, occur at New Horton, but here they dip S. 40° E. $< 30^{\circ}$. Between the two, bright red Lower Carboniferous

sandstones and conglomerates are quite conspicuous, and are apparently conformable under the gray measures. So to the westward, between New Horton and Two Islands, the red and the gray beds form parallel belts, of which the harder strata, becoming gradually more highly tilted, expose their baser edges in prominent ridges, separated by narrow trenches or valleys, all parallel to the shore. Approaching Cape Enragé, the dips rise to 70° or 75°, while at the cape itself, the strata, which are here gray beds, with fossil plants, thick fireclay beds and thin seams of coal, maintain this high dip.

Cape Enragé.

Along the shore of Salisbury cove, at Waterside, the coast section is interesting as exhibiting the unconformable overlapping of Carboniferous conglomerate by Triassic strata in the form of very soft bright-red sandstones dipping S. 40° E. < 20°, but with some irregularity and indications of a low anticline.

Coast section
at Alma

Another interesting coast section is that of the shore just east of Alma, including the conspicuous promontory of the Owl's Head. For about half a mile from the Alma beach, the nearly vertical bluffs are composed of gray sandstones containing many large trunks of trees, more or less carbonized, with also some heavy beds of shale, the whole dipping S. 20° E. < 22°. In nearing the head proper, however, where the bluffs are much higher and quite precipitous, this dip declines until the beds become nearly horizontal, only to rise in the opposite direction, and with such rapidity as, in a short distance, to make the gray beds not only vertical but reversed. Finally, this overturn is cut off by a fault, and along the fault the grey are met by red beds, mostly conglomerate, which slightly overhang the former, while their surfaces on and near the line of contact show abundant slickensides, stained by manganese oxide.

Quaco and
Gardners
creek.

The former wide distribution of Carboniferous sediments in the Bay of Fundy trough, and the extent to which these latter have been affected by disturbances of later origin, are further illustrated by the occurrence of such sediments in isolated patches along the northern side of the bay and their generally tilted and faulted condition. The most considerable of these areas are those of Quaco and Gardners creek. As the details of their structure have been fully described in earlier publications and have only an indirect bearing upon the special subject of this report, they will now be further considered here.

SUB-DIVISIONS OF THE CARBONIFEROUS SYSTEM.

Before proceeding further in the consideration of the Carboniferous system of New Brunswick, it will be necessary to refer to the subdivisions of the system as recognized elsewhere, and especially in the Province of Nova Scotia.

In the reports and maps of the Geological Survey, it has been usual to regard this system in New Brunswick as embracing three principal members, somewhat strongly contrasted in lithological characters and conditions of origin, viz: the Lower Carboniferous, the Carboniferous proper or Coal-Measures, and the newer or Permo-carboniferous, the first consisting of reddish sediments, with evidences of a generally marine origin, the second mostly of gray or purplish, rarely red beds of marsh or fresh water origin, and the third again showing a predominance of red tints, though with it the marine limestones, gypsums and salines which distinguish the Lower Carboniferous formation. In the "Acadian Geology" of Sir William Dawson (1868), the Carboniferous proper was further sub-divided into the "Millstone Grit series" and the "Middle Coal formation;" while with the marine limestones of the Lower Carboniferous division were associated, under the name of the Lower Coal-Measures (in addition to some beds resembling the Middle Coal-Measures) the bituminous deposits known as the Albert shales.

Geological
survey
divisions.

Arrangement
by Sir Wm.
Dawson, 1868.

It has already been stated as regards the peculiar shales last mentioned that there is at present a growing tendency to regard them as of Devonian rather than Carboniferous age, being the equivalents of the fish-bearing and fern-bearing rocks of the Baie des Chaleurs, though very unlike them in their physical aspects. It has also been stated that there are serious objections to this view; but as the question is mainly one of the interpretation of fossils, and has little or no bearing upon the main subject of this report, that of the true coal-bearing rocks, it need not be further considered here. The doubtful beds in question being thus eliminated, the rocks which lie above them are very easily and clearly divisible into two great groups, viz., the Lower Carboniferous formation and the Carboniferous proper, or Coal-Measures, while another, viz., the Upper or Permo-carboniferous is less certainly distinguishable. The characters of these several sub-divisions may be briefly summarized as follows:—

Age of Albert
shales.

Lower Carboniferous.—The lowest beds of this formation, as here limited, are usually coarse conglomerates, their composition and hence

Basal conglom-
erates.

their general appearance varying with the nature of the rocks upon which they rest. They are, however, in almost every instance of a reddish colour, varying from a clear rich red to a dark brownish-red. They are usually also much harder than similar beds higher in the series, and in places are much stained with oxide of manganese. The cement is always to some extent, and often very markedly, calcareous. At some points, as at Quaco Head, St. John county, similar conglomerates are underlaid by beds of limestone, but the principal limestone strata are situated at the summit rather than at the base of the formation. The conglomerates are usually followed by or interstratified with sandstones, also usually of a reddish colour and markedly calcareous. Higher still the beds become finer, embracing shaly and marly deposits, upon which in many instances rest beds of gray flaggy, sometimes bituminous, limestone and heavy beds of gypsum. Between these higher beds and the basal rocks of the coal formation (Millstone Grit) it is common to find extensive sheets of igneous rocks, sometimes in the form of compact diabase, sometimes as a vesicular or amygdaloidal ash rock, and sometimes as claystone or rhyolite; but such plutonic masses are not confined to the summit of the formation, being sometimes, as at Quaco, near its base. Where igneous rocks are associated, as at Quaco, and Hampstead, Queens county, with limestones, the latter have been more or less completely converted into marble.

Thickness
of Lower
carboniferous.

The thickness of the Lower Carboniferous system varies greatly, but, according to measurements made by Dr. R. W. Ells in Albert and Westmorland, it reaches in those counties about 5,000 feet. Its thickness in the central basin is probably much less.

General
absence of
shales.

Coal-Measures.—The contrast between the above described rocks and those of the coal formation is, in the central counties, usually very marked, the bright red colour so characteristic of the one being replaced by an equally characteristic gray colour in the other, while at the same time the strata cease to be calcareous. The basal beds of the coal formation are especially noticeable as being very light coloured, and almost entirely made up of well-rounded pebbles of white quartz. Conglomerates which are somewhat less coarse occur also higher in the series, but with them are beds of coarse sandstone and thinner beds of shale, with, in places, thin seams of coal. Upon the shore of the Baie des Chaleurs about fifty feet of fine shales, gray, green or red in colour, with limestone nodules, extend for several miles in the coastal cliffs about New Bandon, resting upon gray sandstones, but over the larger part of the central coal-field the absence of fine sediments is a noticeable and unpromising feature.

Though gray is the prevailing colour in the rocks of the coal formation. Purple strata, it is necessary to add that it is not unfrequently replaced by a dark purple tint. Occasionally also the beds are reddish, but where this is the case it is always a question whether the rocks so coloured are not of the next division, viz., the newer coal formation or Permo-carboniferous.

The only data available with regard to the thickness of the coal formation in the Central Basin is that to be derived from borings, particulars of which will be given later. The greatest depth attained at Grand lake was 400 feet. At Dunsienne, in Kings county, a depth of 1,200 feet was reached, apparently all in the Carboniferous. In Westmorland county north of Moncton, a depth of 700 feet has been reached in apparently Carboniferous strata. In Albert, where the strata are more highly tilted, the Carboniferous rocks alternate, by displacement, with Lower Carboniferous beds, but never attain any considerable thickness. Thickness of coal formation.

Upper Carboniferous (Permo-carboniferous ?).—In the geological survey maps of South-eastern New Brunswick, a considerable area bordering Baie Verte and portions of Northumberland strait, and extending thence across the Chignecto peninsula to Cumberland basin and Shepody bay, is referred to under the above designations, while in the accompanying report (1884) its author, Dr. R. W. Ellis, describes the group as consisting generally of soft reddish or purple brown sandstone, grits and shales, resting unconformably upon either the Millstone Grit or the Lower Carboniferous. Upon the western side of the Meran- Unconformity gouin peninsula, where one of the unconformable contacts is well exposed, they are estimated, by the author named, to have a thickness of 1,250 feet. As seen in the vicinity of Sackville, they are said to resemble very nearly the sandstones and associated beds of Capes Bald and Tormentine, and of Prince Edward Island.

As the strata in question have not been to any extent personally studied by the writer, and as they enter largely into the comparison of the Carboniferous rocks of New Brunswick and Nova Scotia, a subject to be independently discussed by Mr. H. S. Poole, it will not be necessary further to describe them here.

COAL MINES, COAL CROPS AND BORINGS.

Of the various operations for the removal of coal, the oldest, as well as the most important and instructive, are those of the Grand lake Grand Lake basin.

basin in Queens county. A detailed description of this region and the work done therein may be found in the Report of Progress of the Geological survey for 1872-73. The main facts are as follows:

Estimated
yield of coal.

Structure of
Newcastle
coal basin.

Southern
margin.

Direction and
angle of dip.

With an estimated area (including the Newcastle coal-field, that of Salmon river and Coal of creek), of about 112 square miles, the thickness of the coal formation in the Grand lake basin has been supposed not to exceed 600 feet, and to include but one workable seam of coal, with a usual maximum thickness of only 26 inches, representing nevertheless, with due allowances, an aggregate of nearly 155,000,000 tons. The strata being nearly horizontal, the slight variation in the actual thickness of the coal exposed, together with a careful study of the associated strata (see report referred to above) leaves little doubt that the many openings made reveal in all cases the same bed, while all attempts by boring to ascertain the existence of more deeply seated beds have led only to negative results. At the same time these borings, taken in connection with such natural exposures as are afforded by the river trenches of the district, furnish some information of great importance in its bearing upon the probable thickness and capacity of the coal-bearing rocks elsewhere. Of these stream sections the most important is that of Newcastle river. At the 'forks' of the stream, which enters Grand lake on the northern side, and at a distance of about five miles from Newcastle bridge, the centre of the principal coal-workings of the district, the rocks exposed to view consist of conglomerates which, by their bright red colour, calcareous character and the fact of their association with doleritic and other igneous accumulations, show that they are the representatives of the Lower Carboniferous system or marine portion of the coal formation. In accordance with the same view these red rocks and their volcanic associates are, as elsewhere in the province, directly overlapped by coarse gray quartzose beds, which mark the base of the coal-measures proper or Millstone Grit; all these strata dip southward or towards the lake at a low angle. Thus a northern rim or margin to the Newcastle basin becomes determined. On the southern side of Grand lake, a similar margin is indicated where corresponding coal measures, on the south side of Waskademoak lake, are found resting on the metamorphic hills and dipping northward. Finally, to the eastward of Grand lake, on Coal creek, is a considerable area in which slates, of Devonian age or older, come to the surface. Thus at three points, situated respectively north, east and south of the principal coal-workings at Newcastle bridge, strata older than those of the coal formation are exposed and form the natural rim of the basin. Observing further the dip of the beds on either side, which, though small, leads, as



Coal measures
Lower Carboniferous
and conglomerate

Supposing continuity of Coal Measures to Lower Carboniferous



Coal measures
Lower Carboniferous
and conglomerate

Supposing unconformable deposition of Coal Measures on older and younger conglomerate

DIAGRAMATIC SECTIONS OF THE GRAND LAKE COAL BASIN, QUEENS COUNTY, N.B.

on Newcastle creek, to the gradual replacement of the red by the gray beds, it is only necessary to consider, in connection with this dip, the distance through which it is exhibited, in order to have the data from which to calculate the depth of the whole basin, or that which would be required at any one point to reach the underlying and older rocks. This condition of things, if existing, would be such as is indicated in the first of the accompanying diagrammatic sections :

Evidence of
unconformity.

It will be seen, however, that this conclusion is based upon the supposition of conformity between the Lower Carboniferous rocks and those of the coal-measures, but when put to a practical test this is found not to be in accordance with observed facts. For in drilling through the last named measures at and about Newcastle creek (See Appendix) the latter were indeed found to have been passed through within the depth expected from calculation, actually at little over 200 feet, but the cores brought to the surface, instead of being those of red Lower Carboniferous sediments, as expected, were found to consist of slates similar to those outcropping at the surface along the course of Coal creek. Thus, while the facts abundantly indicate that the basin is in all probability a shallow one, they also indicate that its floor is far from being uniform, either as regards the nature of the rocks composing it or the level at which these stand. Both at Newcastle bridge and at Coal creek the coal-measures rest horizontally on pre-Carboniferous, probably Devonian, rocks, and the whole Lower Carboniferous formation, elsewhere of such great thickness, is wholly wanting. Moreover, if these points represent, as is probable, the crests of ridges subsequently buried by Carboniferous sediments, it may be the case that between the ridges were originally more or less deep valleys, and that while the coal strata burying a ridge might be very thin above the latter, or, as at Coal creek, be entirely removed by later denudation, a short distance on either side of such a ridge a deep valley might exist, and the depth of the coal measures filling such valley be of corresponding proportions. This second view of the question, based upon the known unconformity of the coal measures to the Lower Carboniferous formation and the extensive erosion of the latter, is presented in another section, which, as in the case of that previously given, is theoretical only so far as relates to the parts concealed from view.

If we now pass from the Grand lake or Newcastle coal basin to other parts of the broad central coal field, we find that, so far as outcrops and openings near the surface are concerned, they throw but little additional light upon the question of the total thickness of the coal-formation or its productive capacity.

In the area west of the St. John river, (a minute description of which may be found in the Report of Progress for 1872-73) the most important exposures are those of Clones settlement, near the sources of the Nerepis river, in Queens county. Several seams of coal, in one instance of about three feet, occur here, but the situation, in the bed of a brook, is such as to make the relations of the beds obscure and the removal of coal difficult. It is however worth noting that the general succession seen in this vicinity closely parallels that of the Newcastle basin, Lower Carboniferous strata, such as occur about the head waters of the Nerepis river, and consisting of dark red conglomerates and limestones, being capped by dark olive-gray doleritic and amygdaloidal beds, above which the base of the coal formation is represented by gray conglomerates and grits, of which the former contains pebbles of limestone carrying *Terebratata sacculus* and other characteristic Lower Carboniferous fossils, while the Clones shales, like those of Newcastle, hold remains of ferns, viz : *Cardiocarpa*, *Cordaites* and *Naiadites*, of ordinary coal-measure types. Indications of unconformity between the different members of the system also occur, while, again as at Grand lake, pre-Carboniferous rocks may be seen to protrude through those of Carboniferous age, indicating the uneven bottom upon which these repose.

Of the somewhat numerous outcrops of coal which have at different times been observed in other portions of the area lying west of the St. John river, as on the North-west Oromocto, near Tracy station, (5 inches) on the Otnabog and Mersereau brooks (1 foot), it will not be necessary to speak particularly here, as they reveal no new facts of importance, and the seams themselves are of insignificant thickness. The strata everywhere lie at very low angles, are usually of coarse composition, and, as regards the coal-formation proper, apparently of no great thickness. This latter conclusion may be drawn from the study of the western escarpment of the coal-measures in the vicinity of Cork settlement and Tweedside, as well as from the results of boring operations at Three-Tree creek, near Fredericton junction. In the bluffs of the former the nearly horizontal beds consist mainly of the coarse white-quartz conglomerates so characteristic of the Millstone Grit : at the latter, where a depth of 600 feet was reached, red beds began to appear within 300 feet of the surface.

The above observations refer to the counties of Queens, Sunbury and York. We have now to consider what may be learned from coal crops and borings in the more easterly counties of Kent, Northumberland and Gloucester.

Of coal crops many instances are known, but with one possible exception they are too small to be of any importance. The exception referred to is that of Coal Branch in Kent county. The occurrence of coal at this point was known as early as 1849, when it was examined by Dr. James Robb, who expressed his belief that it might "prove to be the same as the one at the head of Grand lake, from which the sandstones pass continuously, but in an undulating manner." The seam observed was about 15 inches thick and the inclination of the beds N. W. $< 10^\circ$. More recently (1900) boring operations have been undertaken in the same vicinity by the "Canadian Coal and Manganese Company" under the direction of Mr. Pollie, who states that they have drilled through two seams, viz., one of 18 inches occurring 60 feet below the surface and a second of 3 feet at a further depth of 44 feet. Allowance must, however, be made for the fact that the borings were effected with a churn drill and therefore liable to serious misinterpretation. It was the purpose of this company to sink a shaft to the lower of these seams, but results have not been made public. It may be added that the river exposures show but one seam.

Recent
borings.

Borings at
Cocagne river.

A second locality in the county of Kent at which boring operations for coal have been carried on is that of a small brook about two miles from the bridge over Cocagne river. Upon the side of this brook is a pit about 9 feet deep showing 7 inches of coal, overlaid by gray shales, and the site of the bore hole is but a few rods distant from this. The depth reached was 900 feet, but the particulars of the borings I have been unable to obtain.

Dunsinane,
Kings county.

As tending to confirm the belief that, as a consequence of horizontal deposition upon a floor made irregular both by plication and erosion, the rocks of the coal formation, though thin in many places, may be much thicker in others, a glance may now be taken at the facts revealed in the Dunsinane coal area in Kings county. Of comparatively small extent, this area, like that of Queens county, was also for a long time supposed to be of insignificant thickness, forming only a shallow basin over the Lower Carboniferous rocks which outcrop upon its several borders. The strata being known, however, to include seams of coal (one, 22 inches out-cropping at the surface, and another, 12 inches, ten feet and a half lower), the wish to thoroughly prove the ground again led to the undertaking of borings, but with the result that, instead of finding the basin shallow, as had been supposed, the drill actually reached a depth of 1,291 feet, the beds passed through being the coal-measures at the top followed by gray beds nearly to the

bottom, when a few red beds were passed, these latter only being apparently Lower Carboniferous.

The boring referred to, made at a point half a mile from Shives pit (first opened in 1864, on the seams referred to above), and 6,400 feet east of White's pit, indicated one foot of coal at a depth of 239 feet, with thin and irregular streaks of coaly matter at various depths to that of 800 feet or more. The locality was visited by the writer at the time when cores were being taken up from depths between 900 and 1,000 feet. These were mostly sandstones, varying more or less in texture, sometimes becoming coarse grits or fine conglomerates, but always some shade of gray, and not differing in any way from the beds usually characterizing the coal formation elsewhere. If different the lower strata penetrated were, upon the whole, finer than the upper, and included several beds, three or four feet thick, of fine dark shale. An official log of the borings, carefully compared with the cores sent to the Department of Crown Lands at Fredericton, is given in the sequel. It is impossible to draw from these any other conclusion than that the rocks passed through, with the exception of the very lowest, are those of the coal formation, though probably pertaining mainly to its lowest member, the Millstone Grit.

Results of borings.

Outcrops of bituminous coal in Albert and Westmoreland counties are few and unimportant, while the occurrence over large areas of Lower Carboniferous or older rocks, revealed by denudation, would indicate that even where they are concealed by the gray measures the thickness of the latter is but small. Among such outcrops reference may be made to one visited by the writer in company with Mr H. S. Poole, upon Mill brook, in Fairview settlement, two miles and a half from the town of Dorchester, and which has been laid bare by the manager, of the Intercolonial Copper Company. The seam is very inferior, about eight inches thick, and rests upon fire clay and gray shales, which in turn are capped by gray sandstones, dipping S. 20° E. $< 24^{\circ}$. In the shales are found scales, teeth and bones of ganoid fishes, presently to be more particularly referred to, together with plant remains, but the latter are badly preserved. Small seams of coal have also been observed in the vicinity of Shediac and at various points along the Albert county coast, but many of those reported are only the carbonized remains of tree trunks. Off the coast of New Horton, in the same county, a seam of coal, six feet in width, has been stated by residents to be exposed at times beneath the tidal muds half a mile or so from shore, and the fact that the locality is within sight of the Joggins in Nova Scotia, would, if substantiated,

Westmoreland.

New Horton,
Albert county.

give to the observation peculiar interest, but the bed itself is difficult to locate, and, if at all, only in early spring or after severe storms.

Borings at
Lutz moun-
tain.

At Wilson's.

At Harris'.

Boring operations have been carried on quite extensively in Albert and Westmoreland counties, but the object in view has been the discovery of albertite and petroleum rather than of bituminous coal, and the strata penetrated have been for the most part the Albert shales and associated Lower Carboniferous rocks. At a few points, however, the borings have been in the coal-measures, and the object sought ordinary coal. Among such borings are some made in the vicinity of Lutz mountain, nine miles north of Moncton. The so-called "mountain" has already been described in this report as consisting upon its southern side, as revealed in the transverse ravine known as "the Gorge," of coarse red conglomerate of Lower Carboniferous age, and inclined northward at a high angle. Of the borings referred to, two upon the farm of Peter Wilson were to the eastward, while another, upon the Harris property, was to the westward of "the Gorge," the interval being about two miles. In the bore-holes at Wilson's, which were but little removed from the base of the Lower Carboniferous ridge, the records, as might be expected, are remarkable chiefly for the abundance of reddish sediments, indicating that the strata penetrated are either Lower Carboniferous or of a transitional character. Thus, in one bore-hole (No. 2) reddish marls were met at a depth of only 39 feet, and between depths of 200 feet and 600 feet, rocks of this character were the prevailing ones. At another hole, attaining a depth of 625 feet, the first 125 feet were through grayish beds, sometimes becoming purplish, while below this, red beds became increasingly numerous until below 450 feet all the strata were of this colour. In the boring at Harris', on the other hand, which is more distant from the Lower Carboniferous ridge, the prevailing colours are gray and purple, with hardly a trace of red, even the lowest beds, at a depth of over 700 feet, being thus tinted. In all the borings referred to, the rocks are either sandstones or shales, with but little conglomerate, and that only in thin layers.

FOSSILS.

Importance of
fossils.

In previous sections of this report an attempt has been made, by the study successively of the topography, erosion, lithological characteristics and differential movements of the Carboniferous rocks, as well as by reference to the results of mining and boring operations, to reach some practical conclusions as to the thickness of the Carboniferous system in New Brunswick and the occurrence or otherwise of workable coals.

Upon this question the nature of the associated fossils, usually the most important means of fixing geological horizons, would naturally be expected to throw important light. But as in the case of the evidence already considered, the conclusions to be derived from the organic remains of the New Brunswick Carboniferous areas are far from satisfactory. Not that these remains are rare or poorly preserved, as large and good collections have been made at Grand lake, Three Tree creek, New Bandon, Coal Branch and elsewhere, and these have been carefully studied by competent authorities, especially by the late Sir W. Dawson, but many of the forms described by him are peculiar to New Brunswick and hence not comparable with those elsewhere. Besides, authorities are themselves at variance as to how far particular groups of fossils are characteristic of definite horizons. Upon the one hand, a group of rocks not previously referred to in this report, found in various parts of St. John county, and in previous reports described as Devonian (partly upon the results of investigations in the field and partly from the study of the fossils by Sir Wm. Dawson) has quite recently been claimed to be Carboniferous, even though highly metamorphic and unconformably covered by undoubted Lower Carboniferous sediments. Upon the other hand, the rocks of the great central area have been variously referred to the Millstone Grit, to the middle coal formation and to the upper or Permo-Carboniferous group, while even where the Carboniferous system is much more fully represented than here, the vertical range of species and the value of them in fixing time limits are subjects of much discussion.

Discrepancy
of views.

The author of the present report does not feel that he is prepared to offer solutions of these vexed questions, even in the case of the coal field of New Brunswick. He proposes, therefore, merely to give here, in tabular form, lists of the species collected, especially at the localities noted above, and to draw such conclusions as may obviously be derived therefrom.

The following species have been found at Grand lake, and have been referred by Sir William Dawson to the 'middle and upper coal formation':—

Calamodendron approximatum, Brongt.; *Antholites rhabdocarpi*, Daw.; *Calamites Suckowii*, Brongt.; *C. Cisti*, Brongt.; *C. nodosus*, Schlot.; *Asterophyllites grandis*, Stein.; *Annularia sphenophylloides*, Zenker.; *Sphenophyllum emarginatum*, Brongt.; *Cyclopteris* (*Nephropteris*) *obliqua*, Brongt.; *C. (?) Neuropteris*, ingens, L. & H.; *Neuropteris rarineris*, Bunbury; *N. gigantea*, Steinberg; *Sphenopteris munda*, Dawson; *S. latior*, Daw.; *S. gracilis*, Brongt.; *S. artemisifolia*,

Brought. ; *Alethopteris lonchitica*, Steinberg ; *Beinertia Goepperti*, Daws. ; *Palaeopteris Hartii*, Daws. ; *Lepidodendron Pictoense*, Daw. ; *Lepidostrobus squamosus*, Daws. ; *Cordaites borassifolia* Corda ; *C. simplex*, Daws. ; *Cardiocarpum bisectatum*, Daws. ; *Halonina* ?

Of the above list, those in italics occur also upon the shores of the Baie des Chaleurs, about Clifton and New Bandon. In this latter region are found also the following species not discovered at Grand lake :—

Fossils
from Baie
des Chaleurs.

Sphenophyllum saxifragifolium, Stein ; *Neuropteris Loshii*, Brongt. ; *Odontopteris Schlotheimii*, Brongt. ; *Sphenopteris Canadensis*, Daw. ; *S. obtusiloba* ? Brongt. ; *Alethopteris nervosa*, Brongt. ; *A. muricata*, Brongt. ; *A. pteroides*, Brongt. ; *A. Serlii*, Brongt. ; *A. grandis*, Dawson ; *Cordaites simplex*.

Remarking upon the above collections, Sir William Dawson (in 'Acadian Geology,' p. 241) observes that those from the Baie des Chaleurs are 'supposed to belong to the lower set of coal beds in the Middle Coal Measures'; 'those from Grand lake to the upper set of beds.'

To the above lists, as originally given by Sir William Dawson, it is now necessary to add, from the Grand lake region :—

Dadoxylon materiarium, Daws. ; *D. Acadianum*, Daws. ; *Calamites dubius*, Artis ; *Alethopteris nervosa*, Goeppert ; *Neuropteris Loshii*, Brongt. ; *Pecopteris oreopteroides*, Brongt. ; *Lepidodendron Lepidophloris*.

Fossils from
Three-tree
creek.

The following list of species is from collections made by the author of this report at 'Three-tree creek, near Fredericton Junction, and which were identified by Sir William Dawson :—

Neuropteris flexuosa, Steinberg ; *N. cordata*, Brongt. ; *Pecopteris arborescens*, Brongt. ; *Pecopteris oreopteroides*, Stern., or an allied species ; *Pecopteris abbreviata*, Brongt. ; *P.* allied to *P. hirta* ; *Sphenopteris latior*, Daws. *Odontopteris squamosa*, Lesq., or a resembling species ; *Cyclopteris fimbriata*, Lesquereux ; *Lepidodendron Pictoense*, Dawson ; *Lepidostrobus* ; *Cordaites borassifolia*, Unger ; *Annularia equisetiformis*, L. and H. ; *Calamites Cistii* ; Brongt. *Rhabdocarpus* ?

Sir William Dawson remarks that the above plants are of the middle coal formation, and similar to those of Grand lake.

It may be noticed that, in the collections above referred to no occurrences of *Sigillaria* or *Stigmaria* are noted. It must not, how-

ever, from this be inferred that these are absent. The omission is probably wholly accidental. It is certain, at least, that species of *Sigillaria* occur at Grand lake, while large tree trunks, some of which at least are sigillariae and others lepidodendra, but both poorly preserved, have been observed over many portions of the coal field. In the cliffs upon the Bay of Fundy shore, as at New Horton, Cape Enragé and Alma, the occurrence of large drifted tree trunks is especially common, and include, besides *Sigillaria*, *Stigmaria*, *Lepidodendron* and *Dadoxylon*, stems of tree-ferns of the genus *Megaphyton*. In the finer sediments or shales, upon the other hand, here occasionally met with, remains of *Naiadites* are sometimes to be found. In the sea cliffs of Owl's Head, just east of Alma, upon the Albert county coast, an interesting impression was noticed by Mr. Poole and the writer, of which the nature and origin are obscure. It is upon the flat surface of a large block of sandstone detached from the precipitous face of the bluff, and is in the form of two perfectly straight and parallel furrows, each 4 inches wide, about 16 inches apart and about 10 feet long, the space between the furrows being marked by rather regular but obscure depressions, roughly arranged in pairs nearly at right angles to the furrows. The general appearance at a distance of a few yards is that of a huge track, possibly that of a gasteropod, but the nature of the animal producing it, if really thus formed, is very problematical. Fossil track?

Of other animal remains found in the Carboniferous rocks, we have only to mention shells of *Spirorbis*, resembling *S. carbonarius*, found in the shales at Grand lake, and the remains of teeth and scales of Ganoid fishes in similar beds near Dorchester. Coprolites of fishes also occur.

Of the fish remains referred to (found on Mill brook, Fairview settlement, two miles and a half from Dorchester) Dr. Whiteaves writes in a letter to Mr. Poole:—
Fish remains from near Dorchester.

'Judging by the "Acadian Geology," these would seem to be: scales and teeth of *Rhizodus*, presumably of *R. lancifer*; a tooth of *Diplodus*, apparently of *D. penetrans*; and two teeth of a *Ctenoptychius*, perhaps of *C. cristatus*.

'Similar specimens are described and figured on pages 209 to 211 of the "Acadian Geology." On page 211 of that publication teeth of *Diplodus penetrans* are said to occur in the "roof of beds of coal near and above the New Glasgow conglomerate, and on the roof of the main coal."

What the very curious and interesting cone-like organism, with larger, sculptured, imbricating scales at one end, is, I have not been able to find out, but it gives me the impression that it may be a cirrhipede allied to *Plumulites*. Some of the other organisms also I have not been able to make out.'

GENERAL SUMMARY AND PRACTICAL SUGGESTIONS.

Conclusions
arrived at.

In preceding pages the coal problem of New Brunswick has been considered from a number of different standpoints. We may now summarize the conclusions which these several discussions would seem to suggest, and point out some methods of further investigation by which, it is thought, the present uncertainty as to the productive capacity of our coal-fields may be determined.

1. *Topography*.—The approximate uniformity of elevation of the rocks of the coal formation over such vast areas, including nearly one half of the superficies of the province, evidently points to corresponding uniformity of conditions of deposition over the same areas. Hence, if holding productive seams, these may be expected to have wide horizontal distribution, or, if barren at several widely separated areas, to be probably unproductive throughout. This view is in accordance with the facts observed at Grand lake, where all the openings are undoubtedly upon the same seam; and the close correspondence with the latter of the seams observed at Coal Branch in Kent, suggests the idea that these also represent about the same horizon.

Practical
bearing.

From another point of view the topography of the Carboniferous tracts has a practical bearing. It is evident that the very regular triangular form of the great central basin is the result of its inclosure between two great divergent lines of pre-Carboniferous uplift, of which one coincides with or is parallel to the general trend of the great Appalachian uplifts of eastern America, while the other, turning more to the eastward, helps to form the Acadian protaxis which from early times, as now, shut in the depression of the St. Lawrence gulf. The regularity of this divergence and the absence between the two arms of any prominent intermediate elevations would favour the idea that such elevations never existed, while at the same time any minor undulations would be likely to conform in direction with that side of the triangle to which they approximated in position. Indications of the existence of such buried undulations are found in the islands of slate protruding through the Coal formation on Coal creek and the Canaan river, in Queens county, and perhaps, as pointed out by Dr. Ellis, in

the anticline observed along the eastern shore of Kent county and in the outline of the north shore of Prince Edward Island. The exact location of such ridges, as determined by future borings, will, as is evident, constitute an important element in the search for coal, the strata directly above them being necessarily, (as at Grand lake) quite thin, while in their lee, as would seem to have been the case in the Pictou district of Nova Scotia, were present those conditions of shelter and of subsidence which were most favourable for the production of thick beds of coal.

2. *Erosion.*—Facts given upon an earlier page indicated that the rocks of the coal measures were not only laid down upon a floor greatly eroded, but that they have themselves suffered a great diminution of their volume by a like agency. Originally continuous with strata of similar age upon the other shores of the St. Lawrence gulf, they have by submergence and denudation been disconnected with these latter. At the same time their vertical thickness has been greatly reduced, a loss which might involve an important group of coal producing strata. In the Bay of Fundy trough, it can hardly be doubted that such a loss actually occurred.

Effect of erosion.

3. *Attitudes and Unconformities.*—Very low inclinations or absolute horizontality are the prevailing features of the great central basin; somewhat greater irregularity and higher dips are met with in the Kennebecasis and Petitcodiac troughs; great diversity and high dips distinguish the areas bordering upon the Bay of Fundy. A slow subsidence accompanied by a gradual and widespread accumulation of similar sediments are indicated in the first case. Great differential movements, accompanied by important dislocations, mark the regions nearer the coast. As these however, are later in origin than the beds affected, they had little bearing upon the amount of coal which was formed.

Prevailing features of central basin

The unconformities are more important as bearing upon the question of unequal accumulation at different points, the possible thickness at any one point being (as at Grand lake) determined by the attitude as well as by the erosion of the beds below. Unconformity is indicated (1) between the Albert shales and the ordinary Lower Carboniferous sediments, (2) between the Lower Carboniferous sedimentaries and the felspathic and diabasic rocks which frequently cap them, and (3) between the preceding rocks and those of the Millstone Grit. In the central basin, however, such unconformity is usually indicated by partial removal of the lower beds and by overlap rather than by any discordance of dip.

General
prevalence
of coarse
sediments.

Nature of Sediments.—In travelling extensively over the coal-field of New Brunswick, one cannot help being struck by the general prevalence of beds of a coarse character. Naturally these would be more prominent but not more persistent than those of a finer and softer nature, but this fact cannot altogether account for the comparative infrequency of shaly beds. Such beds do indeed occur, and upon the shore of the Baie des Chaleurs are very conspicuously developed, but as a rule, over nearly all parts of the coal-field, the beds exposed, even in river sections, are either conglomerates or coarse sandstones. Such coarse beds of irregular thickness are, of course, not favourable to the occurrence of coal, indicating the prevalence of conditions other than such as led to the formation of the latter. Conglomerates consisting largely of white quartz pebbles are especially abundant around the borders of the great central coal area, and appear to mark the base of the coal measures, though in the Pictou coal-field beds of this character are found in the upper coal-measures, over the thick coal seams.

Colour of
beds.

The colour of the beds has also important bearings; first in the fact that reddish colours, as due to the non-removal of iron compounds by the reducing action of vegetation, tends to indicate the absence of the latter; and, second, because such colour is, to a large extent, distinctive of the Lower Carboniferous formation, and the newer or Permo-carboniferous as distinguished from the Millstone Grit and Coal-measures, which are gray or greenish. Upon this basis partly, but not solely, large areas in Westmoreland county have been referred to the newer or Permo-carboniferous formation.

Thickness.—From what has been stated, it will be evident that there are great possibilities of variation in this respect. Laid down upon a floor characterized by great irregularity of altitude—the result partly of physical movements marking the close of the Devonian age, and partly of erosion during the period of Lower Carboniferous submergence—the coal-measures may be thick or thin, according as they fill up deep depressions of the pre-existing surface, or merely cap the ridges by which they are separated. As a matter of fact, while the thickness at Grand lake is only a few hundred feet, or nothing at all where (as on Coal creek) older strata come to the surface, the depth of the gray series attained at Dunsinane was over a thousand feet. Other examples of pre-Carboniferous strata protruding through the coal-measures occur on the Canaan river and its tributary, Alward brook, in Queens county, and at Lutz mountain and Calhoun's mill in Westmoreland. Several of these islands are obviously in the line of prominent pre-Carboniferous ridges farther west, and the disposition

of the latter thus affords a slight clue to the position of shallow and deep areas of sedimentation to the eastward. As the Carboniferous rocks are mostly wanting in western New Brunswick, and not only spread more widely, but mount higher on the flanks of the inclosing hills as one goes to the eastward, finally covering these latter as on Shepody mountain, it is a legitimate inference that the thickness of the coal formation increases in that direction or towards the Gulf of St. Lawrence, and that this is the direction in which to look for productive coal-seams. It is also to be noticed that in this direction, and closely adjacent to Nova Scotia, is the area in which the most recent or Permo-carboniferous strata are met with, suggesting, though not necessarily proving, that the productive coal measures may be found beneath.

Fossils.—It is to be regretted that such a conflict of opinion should exist as to how far the occurrence of particular species of plants should be regarded as definitely fixing the age of the strata containing them. For evidently, if the fossils found upon the shores of St. John county in highly metamorphic strata, and which are clearly separated from the ordinary coal-measure rocks by marine limestones and volcanic beds, as well as by several unconformities, and appearances of greater antiquity and alteration, can, after having so long been considered as Devonian, now be claimed as of Carboniferous age, the value of such fossils as a means of determining geological equivalency may well be considered as of little moment. In the present state of opinion, therefore, it would be useless to attempt to draw any practical deductions from the study of the fossil flora of the New Brunswick coal-measures. It is, however, worth while to note that in the several publications of the late Sir William Dawson, based upon the most extended researches and familiarity with all the conditions of the problem, the plant bearing beds of Lancaster, near St. John, were regarded as Devonian, while those of Grand lake were described as being of the Middle Coal formation. We may add that the marine Lower Carboniferous sediments rest upon the one and are overlaid by the other, in each case without conformity, and the stratigraphical relation cannot be disputed. We venture to protest against a hasty acceptance of later views, for, if some of these are carried to a conclusion it would mean the elevation of the series now described as Permo-carboniferous to still higher horizons. Finally, even if we regard the whole series of beds referred to the Carboniferous as representing the Millstone Grit, this would by no means preclude the possibility of their carrying workable beds of coal, for such beds are found in rocks of this age in Virginia and elsewhere.

Difference of
opinion as to
age of fossils.

Coal mining
operations.

Mining and Boring Operations.—Mining for coal in New Brunswick has practically been confined to the Grand lake region and to beds but little removed from the surface. The operations there conducted prove the wide horizontal extension of the strata, but throw little direct light upon the thickness of the latter. This, however, has been tested by boring, with the result of showing that in that portion at least of the great coal basin the measures are thin, and are without other seams of coal than the one long worked near the surface. The holes ranged in depth from 170 to 400 feet, and in the deeper ones the cores brought up consisted of shales (probably Devonian) showing that underlying pre-Carboniferous rocks had been reached. At Three-Tree creek also, beds below the Coal Measures were reached at 300 feet or less. These facts, taken in connection with a study of surface outcrops and stratigraphy, seem to indicate that a large part, if not the whole of the coal-bearing rocks in Queens, Sunbury and York, are of shallow depth, and hence unlikely to contain large seams of coal. On the other hand the boring operations at Dunsinane, in Kings county, failing even at 1,200 feet to reach the base of the Carboniferous system, shows that even in small basins and at no great distance from pre-Carboniferous ridges, the coal rocks may attain considerable depth. It is not yet definitely known, however, that the increased thickness is accompanied by any large increase in the number and size of coal-seams. The remaining areas are those of the eastern counties, Northumberland, Kent and Westmorland. No mining operations of any extent have been carried on in this region and the results of borings made only at a few points and for different objects than that of obtaining coal, are inconclusive. The tools used have been churn drills, the logs have been kept by those not fully acquainted with their nature and importance, even the terms used in the description of borings are not alike and often wrong, and the boring sites have been selected with little reference to the geological structure or characteristics of the districts in which they have been placed. This portion of the province therefore, which upon other grounds would seem to be the most promising, is that of which, as yet, the least is known.

Further
borings
necessary.

In view of all the facts now before us there would seem to be only one way of finally settling the still doubtful question as to the thickness and capacity of the New Brunswick coal-field, viz., by borings undertaken in those parts which have not yet been satisfactorily proved. It is not probable that much more can be gained by trials of this sort in the western section of the central coal-field, but it is at least possible that a more favourable set of conditions may be found to exist to the eastward and especially along the shores of the Gulf of

St. Lawrence. To determine this, a methodical series of borings, with a diamond drill taking up solid cores, should be made at different points between Moncton and Bathurst, with at least a few others well located in the Miramichi and Buctouche valleys. From what has been said it will be obvious that there are but few if any features at the surface which can be of much assistance in determining the most favourable location for trial. Each boring would afford presumptive evidence for a considerable area around it, and a series of such holes could hardly leave much doubt as to the general questions involved. Even if the results were wholly negative, they would be of service in removing the present doubt upon the subject, and the possible useless expenditure of large amounts of capital.

While the question of the productive character of other portions of the Carboniferous area is still awaiting investigation, it is satisfactory in the meantime to know that efforts are being made to develop upon a larger scale and in a more systematic way, the deposits already known. Thus with the aid of the provincial government a railway is in course of construction from Chipman, near Grand lake, to Fredericton, which will make it possible to bring the coal from the beds of this region much more readily to market, while much greater care will be taken in the mining and handling of the product, thus avoiding to a considerable extent the crumbling and admixture with foreign matter which has previously done so much to depreciate this coal in the eyes of consumers. In return for the aid afforded by the government, the company building the road binds itself to establish on the line of railway a plant capable of mining an average of not less than 500 tons of coal per day. Owing to the proximity of the seam to the surface—at no point does it lie beneath more than 60 feet of cover, and usually this is much less—the coal can in many cases be most readily obtained by stripping, and machinery will be employed which will allow of this being done with great rapidity. When too deep for this purpose, the coal may still be removed with comparatively little labour by simply cutting trenches from the side of which the coal is removed for a certain distance, and the undermined soil-cap then allowed to fall in. It yet remains to be seen whether the great expectations as to the total yield per year of the field will be realized, but, as pointed out by the author and his associates in 1873, the aggregate amount of coal in the field is large, and, with the present high prices prevailing, should admit of profitable working upon a scale much larger than has been heretofore attempted.

Productive character of Carboniferous area not fully investigated.

Subject of
futur deve-
lopment.

As bearing further upon the subject of future development, I may be permitted to express here my sense of some difficulty, in the study of the Carboniferous tracts of New Brunswick and Nova Scotia arising from the unfortunate method of delineation adopted in the older survey maps, viz., the selection of arbitrary parallel lines to indicate the distinction between sub-divisions of the system. Not only is it almost impossible and very wearying to the eye to separate these, where the areas are small and irregularly associated, but the parallel barring being much more conspicuous than the boundary lines, constantly suggests lines of strike which are false and very misleading. In formations like those of the Millstone Grit and Coal-Measures, where strikes and dips are of the utmost importance to the prospector and miner, everything which would tend to lead to incorrect impressions should be carefully avoided. As the Permo-carboniferous is in these maps already distinguished by difference of tint, it would be well if a similar method could in future maps be employed for the Lower Carboniferous also, especially as this latter formation is so strongly contrasted in its natural coloration, in the nature and origin of its sediments and its relations to agriculture.

APPENDIX

PUBLICATIONS RELATING TO THE CARBONIFEROUS SYSTEM OF NEW BRUNSWICK.

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